



US006089701A

United States Patent [19]

Hashizume et al.

[11] **Patent Number:** 6,089,701[45] **Date of Patent:** Jul. 18, 2000

[54] **INK JET RECORDING HEAD HAVING
REDUCED STRESS CONCENTRATION
NEAR THE BOUNDARIES OF PRESSURE
GENERATING CHAMBERS**

3-65350 3/1991 Japan 347/68
5-504740 7/1993 Japan B41J 2/16
5-286131 11/1993 Japan B41J 2/045

OTHER PUBLICATIONS

[75] **Inventors:** Tsutomu Hashizume; Tetsushi
Takahashi; Akira Matsuzawa, all of
Nagano, Japan

[73] **Assignee:** Seiko Epson Corporation, Tokyo,
Japan

[21] **Appl. No.:** 08/835,748

[22] **Filed:** Apr. 10, 1997

[30] Foreign Application Priority Data

Apr. 10, 1996 [JP] Japan 8-088469
Dec. 9, 1996 [JP] Japan 8-344568
Mar. 17, 1997 [JP] Japan 9-083245

[51] **Int. Cl.⁷** B41J 2/045

[52] **U.S. Cl.** 347/70

[58] **Field of Search** 347/68, 70, 71,
347/72

[56] References Cited**U.S. PATENT DOCUMENTS**

4,296,421 10/1981 Hara et al. 347/68 X
4,516,140 5/1985 Durkee et al. 347/71
4,588,998 5/1986 Yamamuro et al. 347/68
4,897,673 1/1990 Okbayashi et al. 347/68
5,459,501 10/1995 Lee et al. 347/68
5,872,583 2/1999 Yamamoto et al. 347/71 X

FOREIGN PATENT DOCUMENTS

0572230 12/1993 European Pat. Off. .
0698490 2/1996 European Pat. Off. .
4443254 12/1995 Germany .

Patent Abstracts of Japan, vol. 9, No. 14, Jan. 22, 1985, JP
59 164150 A (Nippon Denki K.K.)

Patent Abstracts of Japan, vol. 15, No. 57, Feb. 12, 1991, JP
02 289352 A (Seiko Epson Corp.)

Patent Abstracts of Japan, vol. 7, No. 9, Jan. 14 1983, JP 57
167272 A (Hitachi Seisakusho K.K.)

Patent Abstracts of Japan, vol. 4, No. 179, Dec. 11, 1990, JP
55 126463 A (Ricoh K.K.)

Patent Abstracts of Japan, vol. 8, No. 197, Sep. 11, 1984, JP
59 087167 A (Ricoh K.K.)

Primary Examiner—John Barlow

Assistant Examiner—C Dickens

Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak
& Seas, PLLC

[57] ABSTRACT

An ink-jet recording head comprising: an elastic sheet providing pressure generating chambers; nozzle orifices, each communicating with the pressure generating chamber; piezoelectric vibrators formed on the elastic sheet, each of the piezoelectric vibrators having, a lower electrode formed on the elastic sheet, a piezoelectric layer formed on the lower electrode, and an upper electrode formed on the piezoelectric layer such that the upper electrode faces the respective pressure generating chamber, wherein the upper electrodes of the piezoelectric vibrators are positioned independently of each other; an electrical insulator layer having windows, wherein the electrical insulator layer covers the upper electrodes; and a conductor pattern connecting with the upper electrodes via the windows of the electrical insulator layer.

12 Claims, 7 Drawing Sheets